ENRICHMENT STATUS OF FIFTY-SIX LAKES IN THE CENTRAL REGION OF SOUTHERN ONTARIO

1974

Ontario
Ministry of the Environment

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by

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SUMMARY

In general, the biological quality of the fifty-six lakes as indicated by Secchi disc - chlorophyll *a* measurements was excellent. Only the Earl Rowe Reservoir which is a man-made lake formed by the damming of the Boyne River suffered from poor water clarity and slightly elevated chlorophyll *a* concentrations. Some concern is also expressed relative to the periodically high algal densities encountered in Ada, Black, Bruce and George's Lakes. For lakes having two to three consecutive years of data, only minor positional changes in Secchi disc - chlorophyll *a* relationships were noted, indicating that evidence of accelerating eutrophy is not yet apparent. In order to maintain the excellent water quality which exists throughout much of this part of the province, every effort should be made to ensure that nutrients from sink and laundry wastes, septic tank seepage and garden fertilizers do not gain access to the lakes.

To establish a clearer understanding of year to year variations in water clarity conditions and algal densities, a continuation of the study is recommended. Such information, if maintained on a long-term basis, will be extremely useful in assessing whether or not changes in the trophic condition of the lakes are materializing. In this regard, a suggestion is offered to continue with Secchi disc readings and chlorophyll *a* sampling for three consecutive years, but to maintain Secchi disc readings only during the next three years. The following year, chlorophyll *a* sampling would be re-introduced to complement water clarity data. A number of lakes in the Haliburton Highlands Region now have three successive years of good data available and therefore the chlorophyll *a* sampling part of the programme could be discontinued from 1975 to 1977. Ideally, data collections should be made on a weekly basis during the ice-free period of the year.

INTRODUCTION

Over the past few years an increasing awareness of and concern for problems of pollution in recreational lakes has materialized as a result of accelerated cottage development. Many individual cottagers, cottage associations and permanent shoreline residents have requested that complete water quality evaluations be carried out to assess the degree of pollution in various lakes throughout the province. Exhaustive physical, chemical, bacteriological and biological evaluations for a large number of lakes are beyond the financial and logistical capabilities of personnel involved in water management programmes, and in light of recent studies, are not necessary in order to classify the quality of recreational waters. Appendix A provides a brief explanation of water quality problems in recreational lakes.

In 1971 a relatively simple but effective evaluation programme was carried out on twelve recreational lakes in the Province of Ontario. The programme, which involved the collection of data on water clarity and algal populations, was highly successful owing to the enthusiastic efforts of local residents, cottagers, marina and resort owners and personnel of the Ministry of Natural Resources and the Ministry of the Environment. The success of the programme was exemplified by the fact that in 1972 the number of lakes sampled increased from twelve to thirty-five. The following year ninety-one lakes were sampled in southern Ontario, and in 1974, ninety-eight lakes were sampled.

This report presents the data collected from fifty-six lakes in the Central Region of southern Ontario during the summer of 1974 (see Table 1), incorporates the information into a mathematical relationship and comments on the findings in an attempt to define the current status of enrichment or trophic status of the lakes. The Central Region includes the areas known as the Kawarthas, Haliburton Highlands, Muskokas and Lake Simcoe and the southern part of Georgian Bay.

METHODS

Water clarity which governs the depth of light penetration into a lake is one of the most important parameters used in defining water quality and can be measured using a Secchi disc. The disc is divided into black and white alternating quadrants and is lowered into the water on a graduated line until the quadrants cannot be distinguished. The depth is noted and the disc is

Table 1: Locations of lakes in the Central Region of southern Ontario which were sampled in 1974.

	Lake	Location
1.	Ada	Medora Twp., Dist. Municipality of Muskoka.
2.	Allen	Dudley & Harcourt Twps., Haliburton County.
3.	Arrowhead	Chaffey Twp., Dist. Municipality of Muskoka
4.	Bass	Oro & Orillia Twps., Simcoe County.
5.	Belmont	Belmont Twp., Peterborough County.
6.	Big Hawk	Stanhope Twp., Haliburton County.
7.	Big Straggle	Harcourt Twp., Haliburton County.
8.	Billings	Glamorgan Twp., Haliburton County.
9.	Black	Lutterworth Twp., Haliburton County.
10.	Bob	Anson Twp., Haliburton County.
11.	Boshkung	Stanhope Twp., Haliburton County.
12.	Bruce	Medora Twp., Dist. Municipality of Muskoka.
13.	Butterfly	Medora Twp., Dist. Municipality of Muskoka.
14.	Canning	Minden & Snowdon Twps., Haliburton County.
15.	Chandos	Chandos Twp., Peterborough County.
16.	Clement	Monmouth Twp., Haliburton County.
17.	Davis	Lutterworth Twp., Haliburton County.
18.	Drag	Dudley & Dysart Twps., Haliburton County.
19.	Dudley Bay	(Lake Muskoka) Muskoka Twp., Dist. Municipality of Muskoka.
20.	Eagle	Harburn Twp., Haliburton County.
21.	Earl Rowe	Tosoronto Twp., Simcoe County.
22.	East	Harburn Twp., Haliburton County.
23.	Fairy	Chaffey & Brunel Twps., Dist. Municipality of Muskoka.
24.	George's	Harcourt Twp., Haliburton County.
25.	Haliburton	Harburn Twp., Haliburton County.
26.	Hall's	Stanhope Twp., Haliburton County.
27.	Hardwood	McClintock Twp., Haliburton County.
28.	Harp	Chaffey Twp., Dist. Municipality of Muskoka.
29.	Head	Lexton & Digby Twps., Victoria County.
30.	Horseshoe	Minden Twp., Haliburton County.
31.	Jack	Burleigh & Methuen Twps., Peterborough County.
32.	Joseph	Medora Twp., Dist. Municipality of Muskoka & Humphry Twp., Parry Sound District.
33.	Kashagawigamog	Minden Twp., Haliburton County.
34.	Kennaway	Harcourt Twp., Haliburton County.
35.	Kennisis	Havelock & Guilford Twps., Haliburton County.
36.	Koshlong	Glamorgan Twp., Haliburton County.

Table 1: (Cont'd).

Lake		Location
37.	Kushog	Stanhope Twp., Haliburton County.
38.	Little Kennisis	Havelock Twp., Haliburton County.
39.	Little Straggle	Harcourt Twp., Haliburton County.
40.	Loon	Dudley & Monmouth Twps., Haliburton County.
41.	Looncall	Anstruther Twp., Peterborough County.
42.	Mary	Stephenson & Brunel Twps., Dist. Municipality of Muskoka.
43.	Medora	Medora Twp., Dist. Municipality of Muskoka.
44.	Methuen	Methuen Twp., Peterborough County.
45.	Monrock	Monmouth Twp., Haliburton County.
46.	Morrison	Wood Twp., Dist. Municipality of Muskoka.
47.	Oxtongue	McClintock Twp., Haliburton County.
48.	Pine	Oakley Twp., Dist. Municipality of Muskoka.
49.	Rosseau	Cardwell, Watt & Medora Twps., Dist. Municipality of Muskoka & Humphry Twp., Parry Sound District.
50.	Shadow	Laxton & Somerville Twps., Victoria County.
51.	Soyers	Minden Twp., Haliburton County.
52.	Stormy	Glamorgan Twp., Haliburton County.
53.	Sturgeon Bay	Georgian Bay, Simcoe County.
54.	Twelve Mile	Minden Twp., Haliburton County.
55.	Vernon	Stisted & Chaffey Twp., Dist. Municipality of Muskoka.
56.	Wood	Oakley Twp., Dist. Municipality of Muskoka.

raised slowly until the quadrants are just visible - again the depth is noted. The average of these two depths is termed the Secchi disc depth. As depicted in Figure 1, Secchi disc depths are substantially greater in lakes having low phytoplankton (microscopic free-floating algae) numbers than in lakes characterized by high algal densities and excessive vascular aquatic plant growths. Secchi disc readings were taken as often as possible during the summer of 1974 in the deep-water zones of the fifty-six lakes.

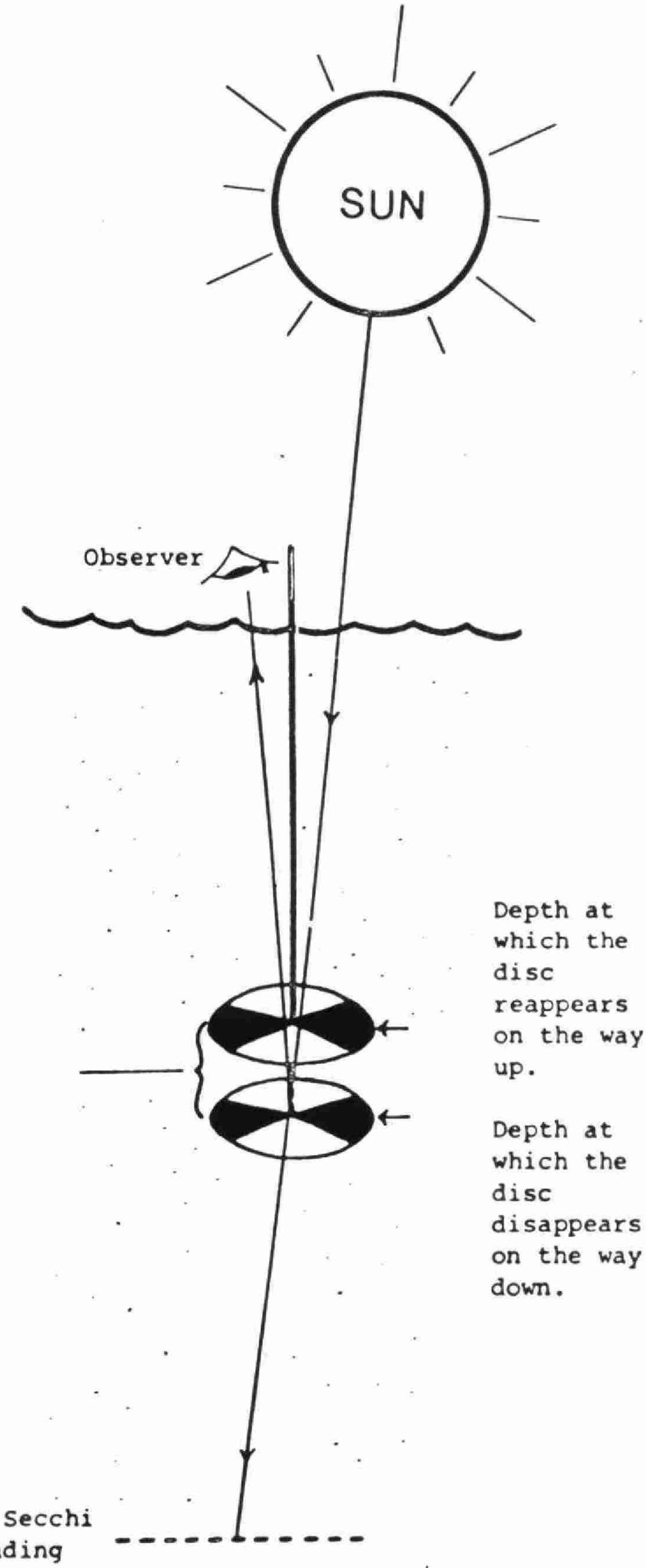
Chlorophyll a is a photosynthetic green pigment in algae and its concentrations can be used as a rough indication of the extent of biological activity in a lake at the time of sampling since it is regulated by all of the combined physical, chemical and biological factors which affect algal production. Chlorophyll a samples were taken on each visit to the lakes by lowering a narrow-mouthed bottle (32 ounce capacity) to the approximate location of the 1% incident light level, or through the zone of effective algal production. The extent of this zone was determined by doubling the value of the Secchi disc depth. The speed of lowering and raising the bottle was regulated so that the bottle was just filled when it reached the surface, the object being to collect a composite water sample from all depths of the measured water column. Ten to fifteen drops of a 2% magnesium carbonate suspension were immediately added to each sample to minimize degradation of the chlorophyll a pigment. Following delivery to the Ministry of the Environment's laboratory facilities in Toronto, the samples were filtered using 1.2 micron filter papers, wrapped in aluminum foil to prevent light from reaching the residue, refrigerated and finally analyzed by staff of the Ministry's Laboratory Services Branch.

DISCUSSION OF RESULTS

Mean Secchi disc values and chlorophyll a concentrations for the fifty-six lakes are presented in Table 2 while individual measurements are summarized in Table 4. It should be realized that in many cases the data represent conditions in July and August only; therefore, the presence or absence of heavy algal growths in the spring and/or fall cannot be confirmed. Some discretion should be exercised when comparing some of these lakes since numbers of Secchi disc readings and chlorophyll a samples varied from lake to lake. For example, only two sets of data were obtained from Bruce,

The "Secchi Disc Reading" is obtained by averaging the depth at which a 20cm (8") dia. black and white plate, lowered into the lake just disappears from view and the depth where it reappears as it is pulled up.

Most of the free-floating algae are suspended in the illuminated region between the lake surface and 2 times the Secchi disc reading.



Clear, algae-free lake: Secchi disc readings tend to be greater than 3m (9 feet).

Turbid or algae-rich lake: Secchi disc readings tend to be less than 3m (9 feet).

Figure 1: Diagram illustrating the use of a Secchi disc to measure water clarity.

Table 2: Summary of the mean values for Secchi disc (meters), chlorophyll a (micrograms per liter) and acidified chlorophyll a (micrograms per liter) data collected from fifty-six lakes in the Central Region during the summer of 1974. Acidified chlorophyll a values are also given as a percentage of the chlorophyll a concentration.

Lake	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)	Percentage (%)
1. Ada	2.6	3.1	2.2	71.0
2. Allen	4.9	1.2	0.8	66.7
3. Arrowhead	2.3	1.9	--	--
4. Bass	2.0	2.4	1.5	62.5
5. Belmont	4.3	1.2	0.6	50.0
6. Big Hawk	6.9	0.7	0.6	85.7
7. Big Straggle	4.8	1.4	1.0	71.4
8. Billings	6.5	0.7	0.5	71.4
9. Black	5.0	3.7	1.3	35.1
10. Bob	4.8	1.9	1.1	57.9
11. Boshkung	--	0.9	0.8	88.9
12. Bruce	3.4	3.6	3.4	94.4
13. Butterfly	3.0	2.8	2.1	75.0
14. Canning	4.8	1.6	1.2	75.0
15a. Chandos - Main Lake	4.5)	0.8)	--	--
15b. Chandos - West Bay	4.2) *	0.7) *	--	--
15c. Chandos - South Bay	4.4)	1.3)	--	--
15d. Chandos - Gilmour Bay	3.0	2.1	--	--
16. Clement	4.3	1.6	1.1	68.8
17. Davis	3.6	1.4	1.1	78.8
18. Drag	6.2	0.6	0.2	33.3
19. Dudley Bay	5.1	0.8	0.6	75.0
20. Eagle	4.2	0.5	--	--
21. Earl Rowe	0.7	6.2	--	--
22. East	3.6	1.5	1.1	73.3
23. Fairy	3.6	12.1	9.3	76.8
24a. George's - Main Lake	2.3) *	3.0) *	1.8) *	52.9
24b. George's - "O"	2.2)	3.9)	1.7)	
25a. Haliburton - Main Lake	6.8	1.1	0.7	63.6
25b. Haliburton - South Bay	3.8	2.4	1.5	63.0
26. Hall's	7.5	0.4	0.2	50.0
27. Hardwood	8.5	0.9	0.6	66.7
28. Harp	3.7	2.1	--	--

Table 2: (continued)

	Lake	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)	Percentage (%)
29.	Head	2.8	2.0	1.8	90.0
30.	Horseshoe	4.6	0.9	0.7	77.8
31a.	Jack - Sharp's Bay	4.4	1.4	1.1	78.6
31b.	Jack - Brook's Bay	3.4	1.9	1.4	73.7
32.	Joseph	7.0	0.7	0.6	85.7
33a.	Kashagawigamog - North	4.4) *	1.4) *	0.8) *	64.3
33b.	Kashagawigamog - South	4.6)	1.5)	1.0)	
34.	Kennaway	3.6	1.9	1.2	63.2
35a.	Kennisis - A	7.7	0.8	0.4) *	50.0
35b.	Kennisis - B	8.6) *	0.5) *	0.4)	75.0
35c.	Kennisis - C	8.6)	0.4)	0.2	
36.	Koshlong	5.4	1.3	0.9	69.2
37.	Kushog	5.0	1.4	0.8	57.1
38.	Little Kennisis	5.3	1.1	0.7	63.6
39.	Little Straggle	3.6	1.6	1.0	62.5
40.	Loon	5.1	0.7	0.4	57.1
41.	Looncall	3.4	1.6	1.3	81.2
42.	Mary	4.5	1.7	0.8	47.0
43.	Medora	3.7	2.0	1.4	70.0
44.	Methuen	5.4	1.9	1.5	78.9
45.	Monrock	2.9	2.3	--	--
46a.	Morrison - 1	2.7) *	0.9) *	0.6) *	60.0
46b.	Morrison - 2	2.7)	1.0)	0.7)	
47.	Oxtongue	3.2	1.2	--	--
48.	Pine	5.0	1.5	0.9	60.0
49.	Rosseau	6.4	0.7	0.6	85.7
50.	Shadow	5.0	1.0	--	--
51.	Soyers	4.4	0.9	--	--
52.	Stormy	2.6	1.4	1.2	85.7
53.	Sturgeon Bay	2.2	1.7	1.0	58.8
54.	Twelve Mile	6.0	1.0	0.8	80.0
55.	Vernon	4.0	0.7	0.1	14.3
56.	Wood	4.5	1.3	1.0	76.9
				Mean	69.1%

*Due to the similarity between stations, values were averaged for Figures 2 and 3.

Horseshoe, Morrison and Shadow Lakes while twenty sets were acquired from Head Lake and nineteen sets from Belmont Lake; consequently, a more realistic appraisal can be made for Head and Belmont Lakes. Those lakes with only one set of data (that is, Bob, Fairy, Loon, Mary and Vernon Lakes) were omitted from all comparisons.

Mean Secchi disc readings were lowest in the Earl Rowe Reservoir where a mean value of 0.7 meters (m)* was obtained. Low readings were also evident in Ada, Arrowhead, Bass, Georges', Head, Monrock, Morrison and Stormy Lakes and Sturgeon Bay. The most transparent lakes were Hall's, Hardwood, Joseph and Kennisis Lakes.

Recent evidence from in-depth studies carried out in Lakes Joseph, Rosseau and Muskoka in the Muskoka Lakes area of the province suggests that lakes having mean Secchi disc readings less than 3m are eutrophic or enriched in nature while those exceeding 5m are oligotrophic or unenriched. Lakes having Secchi disc depths between 3m and 5m would be mesotrophic or moderately productive, that is, they have a moderate level of nutrients, plant growths and biological production. On the basis of these guidelines alone, eighteen lakes (Big Hawk, Billings, Black, Drag, Dudley Bay, Haliburton (Main Lake), Hall's, Hardwood, Joseph, Kennisis, Koshlong, Kushog, Little Kennisis, Methuen, Pine, Rosseau, Shadow and Twelve Mile) would be oligotrophic; twenty-three lakes (Allen, Belmont, Big Straggle, Bruce, Butterfly, Canning, Chandos, Clement, Davis, Eagle, East, Haliburton (South Bay), Harp, Horseshoe, Jack, Kashagawigamog, Kennaway, Little Straggle, Looncall, Medora, Oxtongue, Soyers and Wood) would be mesotrophic; while ten lakes (Ada, Arrowhead, Bass, Earl Rowe, George's, Head, Monrock, Morrison and Stormy Lakes and Sturgeon Bay) would be eutrophic.

In general, chlorophyll a concentrations were low; the highest mean chlorophyll a level was calculated for the Earl Rowe Reservoir (6.2 micrograms per liter-µg/l). High levels were also observed periodically in George's Lake, for example, on September 22 at the Main Lake station a concentration of 6.6 µg/l was obtained and on September 2 at station "0" a concentration of 6.0 µg/l occurred.

Experience has indicated that mean concentrations between 0 and 3 µg/l are low and indicate low to moderate algal densities. Concentrations between 3 and 6 µg/l although moderately high may be considered acceptable for most water-oriented recreational pursuits. Levels exceeding 6 µg/l on a yearly

**Multiply meters (m) by 3.28 to obtain feet.*

average, reflect high algal densities. At these higher levels deterioration of water quality for recreational activities such as swimming and water-skiing may be expected as well as a reduction in aesthetic quality. As indicated in Table 2, chlorophyll a levels in most of the lakes were low, reflecting good water quality conditions. Four lakes (Ada, Black, Bruce and George's) exhibited moderately high mean algal densities, and high algal densities prevailed in the Earl Rowe Reservoir.

As pointed out earlier, Secchi disc readings indicate the depth to which light penetrates into a lake and chlorophyll a is a photosynthetic green pigment in algae. Since light penetration is affected by algal cells suspended in the water, a good correlation should exist between the depth to which light penetrates and the amount of chlorophyll a in a series of lakes of varying degrees of enrichment, assuming that colour and suspended particulate materials (other than algae) interfere minimally with light transmission. Scientists have noted that a "near-hyperbolic" relationship exists between Secchi disc readings and chlorophyll a concentrations. The curve in Figures 2 and 3 depicts this relationships for 3,549 sets of data collected from 220 lakes in the province. Oligotrophic waters which allow significant light penetration and have low chlorophyll a levels lie along the vertical axis of the hyperbola while points for eutrophic or highly enriched lakes are characterized by poor water clarity and high chlorophyll a concentrations and are situated along the horizontal limb. Data for mesotrophic lakes would be dispersed about the middle section of the curve.

Eighteen lakes were positioned in the oligotrophic portion of the curve. Four of these lakes (Hall's, Hardwood, Joseph (1974) and Kennisis) were situated in close proximity to the location established in 1969 and 1970 for Lake Joseph - a highly transparent and relatively unproductive lake in the Muskokas. This relationship was based on the information collected by the Ontario Water Resources Commission (now the Ministry of the Environment) under the Muskoka Lakes Water Quality Evaluation Programme. The remaining lakes were closer to Lake Superior which is also very clear and unproductive. In total, twenty-three lakes were located in the mesotrophic section of the curve. Thirteen of these, including Bruce, Butterfly, Chandos (Gilmour Bay), Davis, East, Haliburton (South Bay), Harp, Jack (Brook's Bay), Kennaway, Little Straggle, Looncall, Medora and Oxtongue Lakes, appear slightly more productive than Allen, Belmont, Big Straggle, Canning, Chandos (Main Lake, West Bay and South Bay), Clement, Eagle, Horseshoe, Jack (Sharp's Bay),

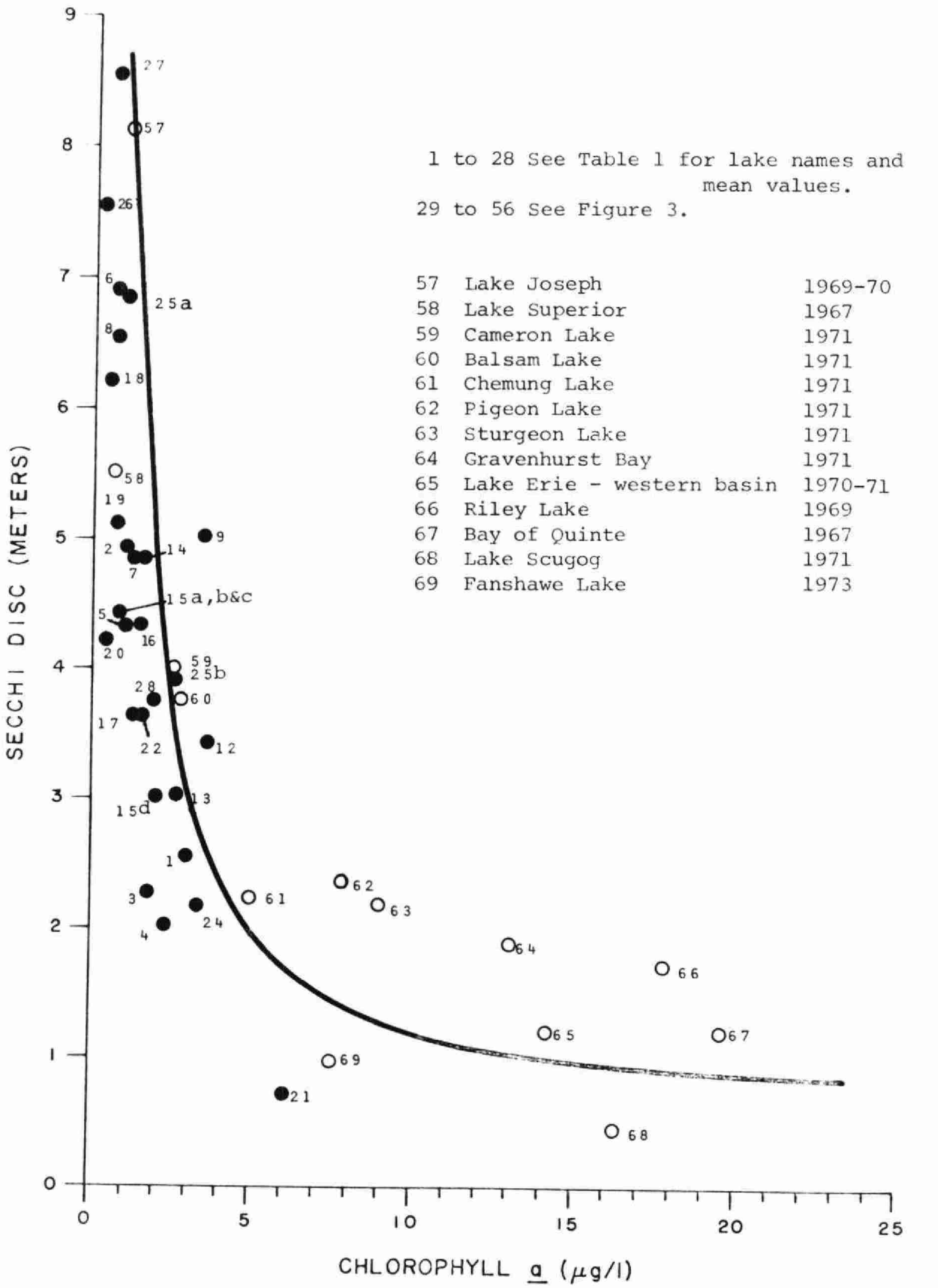


Figure 2: The relationship between Secchi disc and chlorophyll a for 28 of the 56 lakes sampled in the Central Region of southern Ontario. Values for all lakes are based on means of values collected during the summer of 1974. Also, information from a number of other lakes is included as an indication of the relative status of the lakes. Note: Bob's, Boshkung and Fairy Lakes were omitted due to the lack of sufficient data.

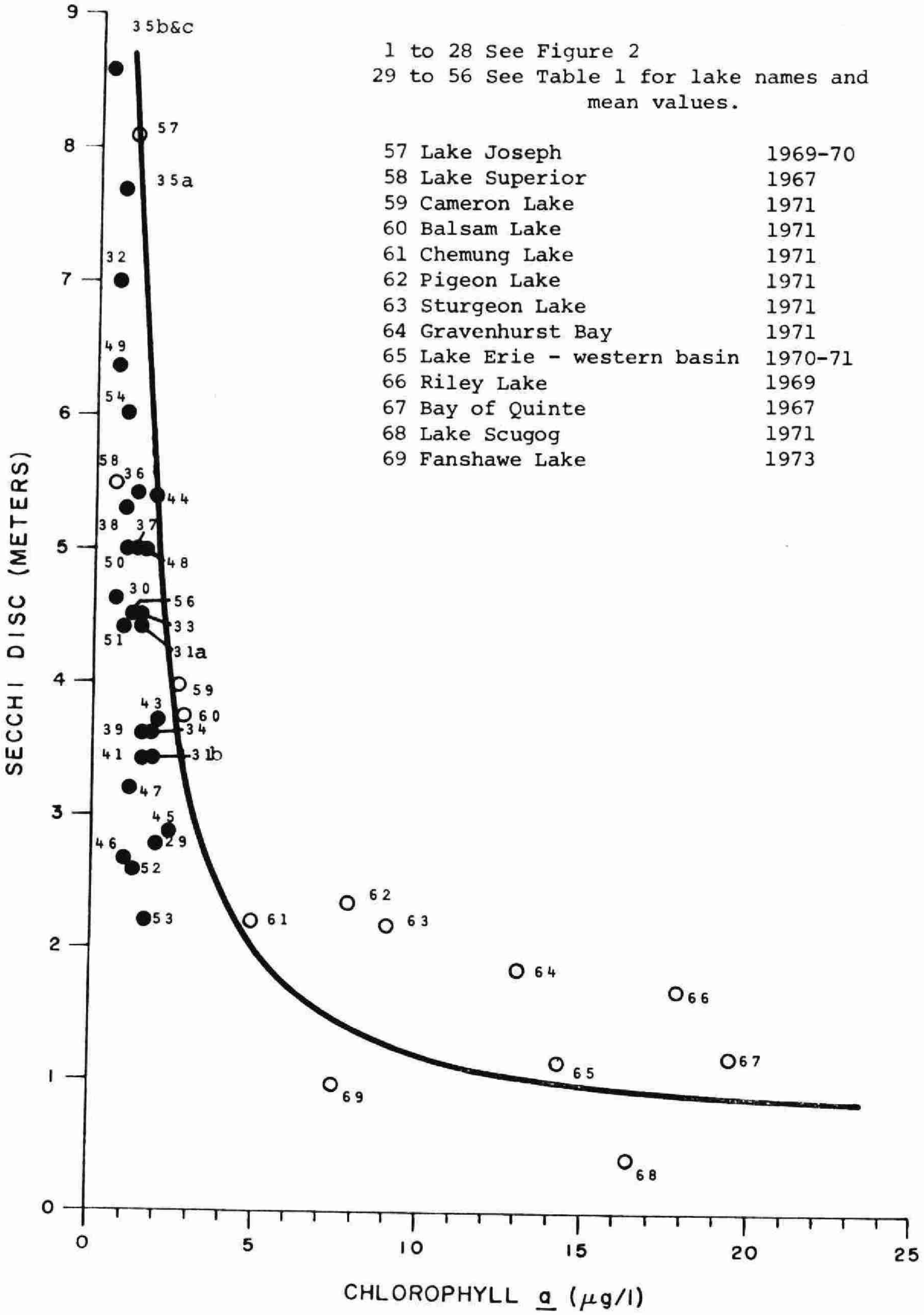


Figure 3: The relationship between Secchi disc and chlorophyll a for the remaining 28 lakes. Again, values for all lakes are based on means of values collected during the summer of 1974. The same lakes included in Figure 2 for comparative purposes are repeated in Figure 3 as an indication of the relative status of these 28 lakes. Note: Loon, Mary and Vernon Lakes were omitted due to the lack of sufficient data.

Kashagawigamog, Soyers and Wood Lakes owing to their close proximity to Balsam and Cameron Lakes - two mesotrophic lakes in the Kawartha Lakes area. The enriched nature of Arrowhead, Bass and George's Lakes and Sturgeon Bay was indicated by their close relation to Chemung, Pigeon and Sturgeon Lakes - three productive lakes in the Kawartha-Trent waterway. Ada, Head, Monrock, Morrison and Stormy Lakes appeared to have slightly better water clarity. The Earl Rowe Reservoir had the lowest Secchi disc readings and highest chlorophyll a values recorded in the Central Region under the Self-Help Programme. It was positioned near Fanshawe Lake (Middlesex County) - a eutrophic body of water. Except for the Earl Rowe Reservoir, all the lakes were well-removed from the highly eutrophic waters of Gravenhurst Bay, the western basin of Lake Erie, Riley Lake, the Bay of Quinte and Lake Scugog.

Many of the lakes now have two or three years of data available (see Table 3) In most cases, annual variations in Secchi disc readings and/or chlorophyll a concentration were minor and could be attributed to year to year variations in sunlight, rainfall, flushing and/or nutrient levels within the watershed of each lake. Clearly defined indications of accelerating eutrophy were not evident. Only Black Lake revealed a slight increase in chlorophyll a concentration from 1973 to 1974. At the same time, Ada, Big Straggle, Davis, Drag, George's, Harp, Horseshoe, Kennaway and Little Straggle Lakes exhibited slight decreases in chlorophyll a levels. Data collected from Dudley Bay, Lake Joseph and Lake Rosseau in 1974 compared well with information acquired under the Muskoka Lakes Water Quality Evaluation Programme.

In Table 2 there are columns labelled "Acidified Chlorophyll a (µg/l)" and "Percentage (%)". Acidified chlorophyll a is a measure of the concentration of chlorophyll a in living algal cells and is a more accurate approximation of the density of algae which are actively growing and reproducing in the water. Any chlorophyll a concentration measured which is in excess of the acidified chlorophyll a concentration is that found in dead algal cells which are still suspended in the euphotic zone at the time of sampling. The acidified chlorophyll a concentration is expressed as a percentage of the chlorophyll a concentration. The data collected from the Central Region of southern Ontario in 1974 would indicate that about 70% of the chlorophyll a in the euphotic zone was in living algal cells. This was the first year that acidified chlorophyll a was measured; eventually it will replace the chlorophyll a measurement.

Table 3: Summary of mean values for Secchi disc (meters) and chlorophyll a (micrograms per liter) data for lakes in the Central Region which have two or more years of data available.

		1974		1973		1972		1971		1970		1969	
		* S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.
Ada		2.6	3.1	2.4	5.0								
Allen		4.9	1.2	4.7	1.3								
Bass		2.0	2.4	2.2	2.6								
Belmont		4.3	1.2			3.7	1.3						
Big Hawk		6.9	0.7	7.2	1.0	6.3	0.8						
Big Straggle		4.8	1.4	4.6	4.0								
Billings		6.5	0.7	6.7	1.0								
Black		5.0	3.7	4.6	2.3								
Bob		4.8	1.9	5.2	2.4								
Boshkung		-	0.9	5.6	2.0	5.6	0.9						
Butterfly		3.0	2.8	3.0	3.0								
Canning		4.8	1.6	5.6	1.8	4.7	3.0						
Chandos	(Main)	4.5	0.8	5.2	1.5								
"	(West)	4.2	0.7	4.7	1.8	3.6	2.2						
"	(South)	4.4	1.3	4.7	1.8								
"	(Gilmour)	3.0	2.1										
Davis		3.6	1.4	4.9	3.7	4.7	1.9						
Drag		6.2	0.6	6.0	2.9								
Dudley Bay		5.1	0.8							5.1	1.4	4.7	1.5
Eagle		4.2	0.5	3.6	1.5								
East		3.6	1.5	5.0	1.9			4.3	2.7				
George's	(Main)	2.3	3.0	2.2	5.8								
"	("O")	2.2	3.9										

Table 3 Cont'd....

		1974		1973		1972		1971		1970		1969	
		S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.
Haliburton	(Main)	6.8	1.1	6.0	1.8								
"	(South)	3.9	2.7										
Hall's		7.5	0.4	7.8	0.7	8.7	0.7						
Harp		3.7	2.1	4.2	3.3								
Head		2.8	2.0	2.9	3.0	3.2	2.8						
Horseshoe		4.6	0.9	5.3	2.3								
Jack	(Sharp's)	4.4	1.4										
"	(Brook's)	3.4	1.9					3.9	2.6				
Joseph		7.0	0.7							8.3	1.1	8.1	1.1
Kashagawigamog	(North)	4.4	1.4	4.6	2.0	4.2	4.7						
"	(South)	4.6	1.5	4.5	1.7								
Kennaway		3.6	1.9	4.1	3.3								
Kennisis	A	7.7	0.8	7.8	0.7	6.7	1.0						
"	B	8.6	0.5	9.5	0.8	9.0	0.9						
"	C	8.6	0.4	9.5	0.8	8.8	0.9						
Koshlong		5.4	1.3	5.7	2.0								
Little Kennisis		5.3	1.1	4.8	1.1	4.4	1.6						
Little Straggle		3.6	1.6	3.8	2.9								
Looncall		3.4	1.6					4.5	1.5				
Oxtongue		3.2	1.2	3.3	2.0	3.6	1.8						
Rosseau		6.4	0.7							6.3	1.9	6.0	1.5
Shadow		5.0	1.0	5.0	0.7	6.0	1.0						
Soyers		4.4	0.9	3.8	1.7								

Table 3 Cont'd....

	1974		1973		1972		1971		1970		1969	
	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.	S.D.	Chloro.
Stormy	2.6	1.4	3.7	1.6	2.8	1.9						
Sturgeon Bay	2.2	1.7	2.7	2.1								
Twelve Mile	6.0	1.0	6.3	1.8	5.8	1.2						

* S.D. - Secchi disc values in meters.

Chloro. - Chlorophyll a values in micrograms per liter.

If continued on a long-term basis, year to year variations in water clarity conditions and algal densities would be extremely useful in assessing whether or not changes in water quality are materializing so that remedial measures could be implemented before conditions become critical. In light of the aforementioned, cottagers should consider a continuation of the Secchi disc - chlorophyll a programme. In this regard, a suggestion is offered to continue with Secchi disc readings and chlorophyll a sampling for three consecutive years, but to maintain Secchi disc readings only during the following three years. In the seventh year, chlorophyll a sampling would be re-introduced to complement water clarity data. As indicated in Table 3, a number of lakes now have three successive years of good data available and therefore chlorophyll a sampling could be discontinued from 1975 to 1977. Ideally, data collections should be made on a weekly basis during the ice-free period of the year.

Table 4: Secchi disc (meters), chlorophyll a (micrograms per liter) and acidified chlorophyll a (micrograms per liter) data collected from fifty-six lakes in the Central Region during the summer of 1974. Mean values are also presented.

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
1. Ada	July 10	2.7	3.5	2.1
	18	2.7	3.6	2.8
	Aug. 1	2.1	3.8	2.9
	7	2.7	2.2	1.4
	21	2.8	2.2	1.8
Mean		2.6	3.1	2.2
2. Allen	June 16	5.8	1.2	0.6
	July 1	4.8	1.1	0.5
	7	5.1	0.7	0.4
	14	4.5	0.5	0.3
	21	6.0	0.5	0.5
	28	4.2	2.0	1.9
	Aug. 5	3.6	2.5	--
	11	4.8	1.5	1.1
	18	4.8	1.2	1.0
	25	4.6	0.9	0.6
	Sept. 2	4.8	1.7	1.4
	8	5.4	1.0	0.9
	15	4.8	0.9	0.7
Mean		4.9	1.2	0.8
3. Arrowhead	June 7	1.8	1.8	--
	Aug. --	2.7	2.5	--
	26	2.4	1.3	--
Mean		2.3	1.9	
4. Bass	May 27	2.1	2.9	2.3
	June 4	2.4	1.1	0.5
	14	2.6	0.6	0.5
	17	2.4	2.1	1.7
	24	2.7	1.3	0.3

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
4. Bass (cont'd)	July 3	1.8	2.6	2.1
	16	1.8	1.5	0.8
	25	2.1	--	--
	29	1.5	3.6	3.2
	Aug. 7	1.5	3.9	3.1
	13	1.5	2.0	1.8
	28	1.8	2.9	--
	Sept. 5	1.8	2.5	0.5
	11	1.6	3.6	--
Mean		2.0	2.4	1.5
5. Belmont	June 19	3.2	1.1	0.8
	26	3.3	1.7	<0.1
	July 11	2.2	2.3	0.8
	17	2.2	0.5	0.1
	24	4.2	0.3	0.1
	31	3.8	0.4	0.3
	Aug. 7	4.4	0.7	0.4
	15	6.4	1.1	--
	21	6.6	0.7	0.7
	29	5.7	0.3	--
	Sept. 5	6.4	--	--
	18	4.6	1.4	<0.1
	26	4.2	1.1	--
	Oct. 4	3.2	1.0	0.5
	9	2.7	2.7	0.6
	19	4.6	2.2	--
	25	3.8	1.1	1.0
	Nov. 3	4.8	0.7	0.3
	11	5.0	2.2	1.9
Mean		4.3	1.2	0.6
6. Big Hawk	June 23	6.9	0.3	<0.1
	July 7	6.3	0.3	0.3
	14	6.6	0.4	0.3

Lake	Date	Secchi Disc (m)	Chlorophyll a (µg/l)	Acidified Chlorophyll a (µg/l)
6. Big Hawk (cont'd)				
	July 21	6.8	0.8	0.7
	28	6.6	0.5	0.2
	Aug. 5	6.6	1.5	--
	11	6.9	1.6	0.9
	18	7.4	0.8	0.6
	25	7.5	0.4	0.3
	Sept. 2	7.2	--	--
Mean		6.9	0.7	0.6
7. Big Straggle	June 2	4.5	2.0	1.2
	8	5.4	3.3	2.7
	16	5.1	2.1	2.1
	23	4.2	1.1	0.9
	30	4.2	1.0	0.6
	July 7	3.6	1.3	1.0
	14	4.2	0.8	<0.1
	21	4.2	0.3	0.1
	28	3.9	1.3	1.3
	Aug. 18	5.4	1.1	1.0
	25	5.7	0.9	0.8
	Sept. 1	5.4	1.6	1.2
	6	5.4	0.8	0.7
	13	5.4	1.2	0.7
	21	5.4	1.6	0.7
	28	5.4	1.3	0.5
Mean		4.8	1.4	1.0
8. Billings	July 28	5.7	0.9	--
	Aug. 18	6.3	0.5	0.3
	Sept. 2	7.5	0.7	0.7
Mean		6.5	0.7	0.5
9. Black	July 28	4.4	3.9	--
	Aug. 6	5.0	5.2	--
	11	4.2	2.7	--
	18	5.4	2.6	1.8
	Sept. 2	6.0	4.1	0.8
Mean		5.0	3.7	1.3

Lake		Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
10. Bob*	1	Oct. 6	4.8	1.3	0.8
	2	6	4.8	1.4	1.0
	3	6	4.8	1.3	0.9
	4	6	4.8	1.7	1.0
	5	6	4.8	2.3	1.5
	6	6	4.8	3.4	1.6
Mean			4.8	1.9	1.1
11. Boshkung		July 1	--	1.0	--
		21	--	0.3	0.3
		Aug. 25	--	1.4	1.2
Mean				0.9	0.8
12. Bruce		Sept. 15	3.2	3.2	--
		Oct. 3	3.6	4.1	3.4
Mean			3.4	3.6	3.4
13. Butterfly		July 10	3.4	3.8	2.6
		18	3.3	1.6	1.1
		24	3.3	0.9	0.6
		Aug. 1	2.4	5.1	3.9
		7	2.4	3.0	2.3
		21	3.0	2.2	1.9
Mean			3.0	2.8	2.1
14. Canning		June 16	5.0	0.7	--
		23	4.8	0.9	0.6
		July 1	3.8	4.7	4.0
		6	4.2	2.0	--
		14	4.2	0.5	--
		21	6.0	2.1	--
		28	5.4	1.2	0.7
		Aug. 4	4.8	1.5	--
		24	5.4	1.2	0.7
		Sept. 2	4.4	--	--
		15	4.8	1.4	0.4
		29	4.2	1.0	0.5
Mean			4.8	1.6	1.2

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
15. Chandos - Main Lake	June 3	4.5	--	--
	19	4.4	0.6	--
	27	6.0	0.8	--
	July 8	3.9	0.7	--
	22	4.2	1.1	--
	Aug. 21	3.8	0.7	0.5
Mean		4.5	0.8	--
West Bay	June 3	3.6	--	--
	19	4.5	0.7	--
	27	5.7	1.0	--
	July 8	4.2	0.6	--
	22	3.9	0.8	--
	Aug. 21	3.6	0.4	0.1
Mean		4.2	0.7	--
South Bay	June 3	3.8	2.7	--
	19	4.6	0.9	--
	27	5.4	1.1	--
	July 8	4.8	0.7	--
	22	3.9	--	--
	Aug. 21	3.9	1.0	0.7
Mean		4.4	1.3	--
Gilmour Bay	July 22	2.7	3.7	--
	Aug. 24	3.2	0.5	0.3
Mean		3.0	2.1	--
16. Clement	June 9	4.4	1.2	<0.1
	16	4.5	0.9	0.3
	23	5.0	1.5	0.7
	July 7	4.6	2.6	2.2
	13	4.4	0.5	0.3
	21	4.0	2.2	2.1
	28	3.9	2.2	2.0
	Aug. 11	3.3	1.5	--
Mean		4.3	1.6	1.1

Lake	Date	Secchi Disc (m)	Chlorophyll *a* (μg/1)	Acidified Chlorophyll *a* (μg/1)
17. Davis	July 14	3.9	1.6	--
	28	3.8	2.2	1.8
	Aug. 11	3.2	1.1	1.1
	25	3.3	1.3	0.9
	Sept. 8	--	0.8	0.5
Mean		3.6	1.4	1.1
18. Drag	July 14	6.9	0.3	0.2
	28	6.0	0.6	--
	Aug. 11	6.0	0.8	--
	25	5.8	0.7	0.2
	Sept. 8	--	0.4	0.3
Mean		6.2	0.6	0.2
19. Dudley Bay	July 10	4.0	1.0	0.7
	18	6.0	0.8	0.5
	24	4.5	0.6	0.5
	Aug. 1	4.2	0.7	0.6
	7	6.3	1.0	0.8
	21	5.7	0.5	0.7
Mean		5.1	0.8	0.6
20. Eagle	June 2	4.0	0.2	--
	16	3.4	0.2	--
	July 14	4.5	0.8	--
	27	4.5	0.8	--
	Aug. 11	3.6	0.5	--
	25	5.8	0.5	--
Mean		4.2	0.5	
21. Earl Rowe Reservoir* 5	--	0.9	10.0	--
	July 19	0.4	7.3	--
6	--	0.8	3.6	--
	July 19	0.4	7.6	--
-	Aug. 21	0.9	2.3	--
Mean		0.7	6.2	

Lake	Date	Secchi Disc (m)	Chlorophyll a (µg/l)	Acidified Chlorophyll a (µg/l)
22. East	June 2	5.2	3.7	2.1
	9	3.9	2.0	1.6
	16	3.4	2.3	2.3
	23	3.4	0.6	0.6
	30	3.4	1.2	0.9
	July 7	3.8	1.0	0.4
	14	3.4	1.3	0.8
	21	3.4	0.6	0.3
	28	3.8	2.0	1.7
	Aug. 5	3.0	1.3	--
	11	3.4	1.1	0.7
	18	3.9	1.7	1.1
	25	4.0	0.5	0.4
	Sept. 1	3.2	1.5	1.4
	22	3.2	1.1	--
Mean		3.6	1.5	1.1
23. Fairy	Aug. 28	3.6	12.1	9.3
24. George's - Main Lake	June 2	2.7	3.0	2.0
	8	2.4	2.3	1.8
	16	2.1	2.5	0.1
	23	2.6	0.9	--
	July 1	2.0	2.9	2.3
	7	2.1	2.0	--
	14	2.4	2.5	0.8
	21	2.2	1.1	0.6
	28	2.4	3.8	3.2
	Aug. 5	2.0	3.8	--
	12	2.2	3.2	2.6
	18	2.2	3.6	--
	25	2.2	1.0	--
	Sept. 2	2.2	4.5	3.4
	8	2.4	2.1	1.3
	15	2.6	4.9	--
	22	2.4	6.6	--
	29	2.2	4.2	1.8
Mean		2.3	3.0	1.8

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
"o"	July 7	2.4	2.0	--
	Aug. 5	2.0	3.7	--
	Sept. 2	2.0	6.0	--
	29	2.2	3.9	1.7
Mean		2.2	3.9	1.7
25. Haliburton - Main Lake	July 1	--	1.8	--
	7	6.3	1.8	--
	13	6.3	1.2	0.8
	21	--	0.4	0.4
	Aug. 11	6.0	1.3	0.9
	18	--	1.2	0.5
	25	6.6	1.7	1.3
	Sept. 2	7.2	--	--
	7	8.4	0.4	0.1
	Oct. 13	6.0	1.1	--
Mean		6.7	1.1	0.7
South Bay	July 1	--	3.5	--
	7	3.9	3.5	2.5
	13	4.2	3.8	2.4
	21	--	1.6	1.5
	Aug. 11	4.2	1.5	0.1
	18	3.9	3.6	2.0
	25	3.6	2.6	2.0
	Sept. 2	3.6	--	--
	7	4.2	1.5	1.2
	Oct. 13	3.0	0.2	<0.1
Mean		3.8	2.4	1.5
26. Hall's	July 14	6.9	0.4	0.4
	21	--	0.3	0.2
	28	7.8	0.5	--
	Aug. 5	7.5	0.2	--
	9	--	0.3	0.1
	18	7.8	0.4	0.2
Mean		7.5	0.4	0.2

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
27. Hardwood	June 2	7.0	0.6	0.4
	16	9.9	1.0	0.6
	23	10.5	1.0	0.7
	July 1	11.1	0.9	0.7
	15	8.0	1.0	0.1
	21	8.1	0.8	0.7
	28	9.0	0.9	0.9
	Aug. 4	6.9	0.9	--
	20	6.4	0.6	<0.1
	Sept. 15	8.4	1.2	1.2
Mean		8.5	0.9	0.6
28. Harp	May 20	5.2	0.9	--
	June 9	4.6	2.9	--
	16	3.3	4.0	--
	30	3.3	0.3	--
	July 28	3.3	3.0	--
	Aug. 4	3.0	1.4	--
	11	3.6	3.6	--
	17	3.3	0.7	--
Mean		3.7	2.1	
29. Head	May 20	3.2	0.4	0.2
	26	2.4	3.3	2.9
	June 9	2.8	1.8	--
	16	3.0	2.5	--
	23	2.7	0.5	--
	July 1	3.2	0.9	--
	7	3.0	2.3	1.5
	14	3.0	--	--
	21	3.2	1.5	--
	28	2.8	2.2	2.0
	Aug. 5	2.6	1.9	--
	11	2.8	1.9	1.7
	18	2.8	3.8	3.2
	25	2.6	1.0	0.6

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
29. Head (cont'd)	Sept. 2	2.6	4.4	3.8
	8	2.8	3.1	3.1
	15	2.7	2.0	1.6
	22	2.7	1.3	0.6
	29	2.4	2.9	1.5
	Oct. 6	2.7	0.4	0.3
Mean		2.8	2.0	1.8
30. Horseshoe	Aug. 11	--	0.9	0.7
	Sept. 2	4.6	--	--
Mean		4.6	0.9	0.7
31. Jack - Sharp's Bay	May 26	2.8	0.7	0.4
	June 2	4.4	1.0	0.9
	9	4.4	1.4	--
	16	4.4	3.1	2.6
	24	4.6	2.0	1.8
	30	5.2	1.3	1.0
	July 14	5.2	1.3	1.0
	21	4.8	1.4	1.4
	28	4.5	1.1	0.2
	Sept. 2	4.5	1.6	1.4
	15	4.2	1.3	1.3
	22	4.8	1.3	0.2
	29	3.9	1.4	0.8
Mean		4.4	1.4	1.1
Brook's Bay	May 26	3.2	0.7	0.5
	June 2	3.2	1.6	1.2
	9	3.4	1.4	--
	16	4.0	2.9	2.5
	24	2.8	1.9	1.8
	30	3.2	1.3	0.9
	July 14	3.0	2.0	1.5
	21	3.6	2.5	1.3
	28	3.6	2.7	2.4

Lake	Date	Secchi Disc (m)	Chlorophyll a (µg/l)	Acidified Chlorophyll a (µg/l)
31. Jack (cont'd)	Sept. 2	3.8	2.3	1.9
- Brook's Bay	15	3.9	1.7	1.5
	22	3.3	2.2	0.6
	29	3.9	1.8	0.8
Mean		3.4	1.9	1.4
32. Joseph	July 18	7.4	0.6	0.3
	24	6.6	0.4	0.4
	Aug. 1	7.8	1.4	1.2
	7	7.4	0.5	--
	21	5.8	0.5	0.5
Mean		7.0	0.7	0.6
33. Kashagawigamog - North	June 16	3.9	0.7	0.4
	23	3.0	1.2	0.9
	July 1	3.6	3.7	--
	7	4.5	1.2	0.8
	13	4.8	0.8	0.5
	21	4.8	2.0	1.6
	28	4.5	1.4	0.9
	Aug. 5	5.1	1.2	1.2
	11	5.1	1.1	--
	25	5.4	1.7	0.9
	Sept. 2	4.5	--	--
	8	3.9	0.5	0.3
	22	3.9	2.7	1.0
	Oct. 6	3.9	0.6	0.3
Mean		4.4	1.4	0.8
- South	July 1*	3.0	2.4	1.8
	7*	4.3	1.1	0.8
	14	4.5	0.7	0.3
	20	5.1	2.0	1.5
	28	3.9	0.9	0.7
	Aug. 5	5.4	2.7	--
	25	6.0	0.7	0.6
Mean		4.6	1.5	1.0

Lake		Date	Secchi Disc (m)	Chlorophyll a (µg/l)	Acidified Chlorophyll a (µg/l)
34. Kennaway		June 16	4.5	1.8	--
		23	3.3	1.7	1.0
		July 1	3.4	1.7	1.4
		7	3.4	1.3	0.8
		14	3.2	0.7	0.4
		21	3.4	1.8	0.7
		28	3.4	1.8	1.5
		Aug. 5	3.4	1.5	--
		11	3.8	1.0	0.7
		18	4.0	1.9	1.9
		25	4.4	1.8	1.5
		Sept. 2	3.8	3.0	1.9
		8	3.6	1.5	1.0
		15	3.2	3.1	2.6
		22	3.8	3.6	0.8
Mean			3.6	1.9	1.2
35. Kennisis	A	July 14	6.2	0.5	0.1
		20	7.5	0.7	--
		28	7.2	1.2	--
		Aug. 5	7.5	1.3	1.2
		11	4.8	0.3	0.1
		18	8.1	0.5	0.4
		25	9.0	--	--
		31	9.6	--	--
		Sept. 7	10.5	0.2	0.1
		15	6.8	1.3	0.6
Mean			7.7	0.8	0.4
	B	July 14	7.5	0.6	--
		21	8.7	0.4	--
		28	8.1	0.5	0.3
		Aug. 4	7.2	0.7	--
		11	8.1	0.4	<0.1
		18	9.0	0.4	0.2
		25	12.0	0.4	0.4
Mean			8.6	0.5	0.4

Lake	Date	Secchi Disc (m)	Chlorophyll a (µg/l)	Acidified Chlorophyll a (µg/l)
36. Koshlong	June 16	4.2	0.7	<0.1
	23	5.1	0.9	<0.1
	July 1	4.8	1.7	1.5
	7	5.2	1.8	1.4
	14	5.1	1.0	0.5
	21	6.0	2.5	1.8
	28	6.0	1.5	0.5
	Aug. 4	5.1	1.7	1.6
	11	6.3	1.2	0.8
	25	6.2	0.4	0.3
	Sept. 2	5.7	--	--
Mean		5.4	1.3	0.9
37. Kushog	July 9	5.7	0.3	0.1
	19	4.4	1.7	1.1
	Aug. 5	5.2	2.3	--
	11	4.6	1.4	1.0
	21	5.4	1.4	0.9
	Sept. 2	5.0	--	--
Mean		5.0	1.4	0.8
38. Little Kennisis	July 14	3.4	1.1	0.8
	20	4.6	0.9	--
	28	5.0	1.8	--
	Aug. 5	4.5	0.2	0.2
	11	7.4	1.2	1.0
	18	5.4	1.0	0.7
	25	5.7	--	--
	31	6.0	--	--
	Sept. 7	5.6	0.9	0.8
	15	5.7	1.8	0.7
Mean		5.3	1.1	0.7
39. Little Straggle	June 16	4.5	2.6	1.7
	23	3.2	1.2	1.0
	30	3.4	1.8	1.3
	July 7	3.2	1.3	0.9

Lake		Date	Secchi Disc (m)	Chlorophyll a (μg/1)	Acidified Chlorophyll a (μg/1)
39. Little Straggle (cont'd)		July 14	3.3	0.7	0.1
		21	3.4	1.6	1.1
		28	3.8	1.7	1.6
		Aug. 1	3.2	1.8	--
		18	3.9	1.6	1.0
		25	4.0	1.2	1.0
		Sept. 1	4.0	1.7	1.4
		22	3.3	1.6	0.5
Mean			3.6	1.6	1.0
40. Loon*	1	Aug. 15	5.0	0.5	0.3
	2	15	5.0	0.6	0.1
	3	15	5.4	0.5	0.1
	4	15	5.4	0.5	0.5
	5	15	5.6	0.7	0.3
	6	15	5.6	0.5	0.4
	7	15	4.5	1.2	0.7
	8	15	4.5	0.8	0.7
Mean			5.1	0.7	0.4
41. Loon Call		May 26	3.3	4.6	4.4
		June 2	3.9	1.3	0.8
		9	3.9	4.3	4.2
		16	3.9	0.6	0.5
		23	3.6	0.7	0.4
		July 1	2.6	1.1	0.7
		7	3.0	1.2	1.0
		14	2.6	2.8	2.0
		Aug. 11	3.0	1.1	0.7
		18	3.9	1.4	0.9
		25	3.3	0.3	0.2
		Sept. 2	3.3	1.2	1.0
		22	3.3	0.9	0.3
Mean			3.4	1.6	1.3
42. Mary		Aug. 28	4.5	1.7	0.8

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
43. Medora	May 20	3.9	0.6	0.3
	26	3.8	0.3	0.2
	June 2	4.2	0.5	0.3
	July 2	3.4	1.5	1.1
	8	3.6	2.5	1.9
	15	3.0	1.2	0.8
	29	2.6	1.7	1.4
	Aug. 11	4.0	2.5	1.9
	18	4.5	4.0	3.6
	26	--	3.2	2.6
	Sept. 3	4.5	4.2	2.7
	8	3.3	2.2	1.2
	15	3.6	3.2	2.3
	Oct. 13	3.3	0.1	<0.1
Mean		3.7	2.0	1.4
44. Methuen	July 28	6.2	2.0	--
	Aug. 5	4.6	1.5	--
	11	4.6	2.1	1.3
	18	5.7	1.8	1.6
	25	6.0	2.0	1.6
Mean		5.4	1.9	1.5
45. Monrock	Aug. 26	2.8	2.3	--
	Sept. 2	3.0	2.8	--
	15	3.0	1.8	--
Mean		2.9	2.3	
46. Morrison 1	Sept. 15	2.7	1.2	0.9
	Oct. 15	2.7	0.6	0.3
Mean		2.7	0.9	0.6
2	Sept. 15	2.7	1.2	1.0
	Oct. 15	2.7	0.8	0.3
Mean		2.7	1.0	0.7

Lake		Date	Secchi Disc (m)	Chlorophyll a (µg/l)	Acidified Chlorophyll a (µg/l)
47. Oxtongue		June 2	3.0	1.1	--
		22	2.7	0.1	--
		July 1	3.0	0.8	--
		7	3.2	1.0	--
		21	3.6	1.7	--
		Aug. 5	4.0	2.5	--
	Mean		3.2	1.2	
48. Pine		July 14	5.2	1.5	1.1
		21	6.3	1.6	1.3
		29	3.6	0.9	0.7
		Aug. 5	4.4	1.4	--
		12	6.3	1.2	1.1
		18	6.3	1.3	0.8
		26	4.8	0.8	0.6
		Sept. 2	5.1	2.2	1.9
		8	5.4	2.4	1.7
		22	3.3	2.2	<0.1
		Oct. 6	4.8	0.7	<0.1
	Mean		5.0	1.5	0.9
49. Rosseau		July 10	7.5	0.9	0.8
		18	5.8	0.6	0.3
		24	6.6	0.5	0.5
		Aug. 1	6.4	1.0	0.9
		7	6.4	0.7	0.6
		21	5.4	0.7	0.7
	Mean		6.4	0.7	0.6
50. Shadow		July 21	4.8	0.8	--
		28	5.1	1.1	--
	Mean		5.0	1.0	
51. Soyers		July 21	4.0	0.8	--
		Aug. 5	4.4	0.8	--
		18	5.0	0.8	--
		24	4.4	1.2	--
	Mean		4.4	0.9	

Lake	Date	Secchi Disc (m)	Chlorophyll a (μg/l)	Acidified Chlorophyll a (μg/l)
52. Stormy	July 1	3.0	2.9	2.3
	14	2.4	0.1	<0.1
	Aug. 5	2.7	2.1	--
	18	2.4	0.4	0.2
	Sept. 1	1.8	--	--
	16	1.8	1.4	0.9
Mean		2.4	1.4	0.9
53. Sturgeon Bay	May 9	1.5	0.2	--
	22	2.6	1.9	1.5
	June 5	2.3	0.6	0.4
	18	1.4	3.2	2.2
	July 6	2.1	2.0	--
	19	2.5	2.5	1.0
	28	2.4	1.8	1.6
	31	2.6	3.1	--
	Aug. 12	2.2	0.9	0.5
	18	2.7	0.7	0.5
	25	3.0	0.7	0.6
	27	2.5	1.5	1.1
	Sept. 25	1.7	1.1	0.4
	Oct. 22	2.1	4.2	--
Mean		2.2	1.7	1.0
54. Twelve Mile	May 20	5.2	1.1	0.9
	July 6	6.9	0.6	--
	14	--	0.5	--
	21	6.0	1.3	1.2
	28	6.0	0.9	--
	Aug. 5	6.2	0.8	0.7
	11	6.8	1.2	1.0
	18	6.6	0.9	0.5
	25	5.8	1.1	0.9
	Sept. 5	4.6	1.6	0.5
	Oct. 12	--	0.6	--
Mean		6.0	1.0	0.8

Lake	Date	Secchi Disc (m)	Chlorophyll _a_ (μg/l)	Acidified Chlorophyll _a_ (μg/l)
55. Vernon	Aug. 28	4.0	0.7	0.1
56. Wood	July 1	4.2	1.3	1.2
	7	4.0	1.1	0.9
	14	3.3	0.6	0.6
	21	4.5	0.7	0.4
	29	4.5	1.8	1.6
	Aug. 5	4.4	1.7	--
	11	4.5	1.8	1.7
	18	5.4	1.3	1.1
	23	6.0	0.7	0.4
	Sept. 15	3.9	1.6	0.9
Mean		4.5	1.3	1.0

*Due to lack of sufficient information, all values were averaged.

APPENDIX A

INFORMATION OF GENERAL INTEREST TO COTTAGERS

MICROBIOLOGY OF WATER

For the sake of simplicity, the micro-organisms in water can be divided into two groups; the bacteria that thrive in the lake environment and make up the natural bacterial flora; and the disease causing microorganisms, called pathogens, that have acquired the capacity to infect human tissues.

The "pathogens" are generally introduced to the aquatic environment by raw or inadequately treated sewage, although a few are found naturally in the soil. The presence of these bacteria does not change the appearance of the water but poses an immediate public health hazard if the water is used for drinking or swimming. The health hazard does not necessarily mean that the water user will contract serious waterborn infections such as typhoid fever, polio or hepatitis, but he may catch less serious infections of gastroenteritis (sometimes called stomach flu), dysentery or diarrhea. Included in these minor afflictions are eye, ear and throat infections that swimmers encounter every year and the more insidious but seldom diagnosed, subclinical infections usually associated with several water born viruses. These viral infections leave a person not feeling well enough to enjoy holidaying although not bedridden. This type of microbial pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satifactory conditions within a relatively short time (approximately 1 year) since disease causing bacteria usually do not thrive in an aquatic environment.

The rest of the bacteria live and thrive within the lake environment. These organisms are the instruments of biodegradation. Any organic matter in the lake will be used as food by these organisms and will give rise in turn to subsequent increases in their numbers. Natural organic matter as well as that from sewage, kitchen wastes, oil and gasoline are readily attacked by these lake bacteria. Unfortunately, biodegradation of the organic wastes by organisms uses correspondingly large amounts of the dissolved oxygen. If the organic matter content of the lake gets high enough, these bacteria will deplete the dissolved oxygen supply in the bottom waters and threaten the survival of many deep water fish species.

RAINFALL AND BACTERIA

The "Rainfall Effect" relates to a phenomenon that has been documented in previous surveys of recreational lakes. Heavy precipitation has been shown to flush the land area around the lake and the subsequent runoff will carry available contaminants including sewage organisms as well as natural soil bacteria with it into the water.

Total coliforms, fecal coliforms and fecal streptococci, as well as other bacteria and viruses which inhabit human waste disposal systems, can be washed into the lake. In Precambrian areas where there is inadequate soil cover and in fractured limestone areas where fissures in the rocks provide access to the lake, this phenomenon is particularly evident.

Melting snow provides the same transportation function for bacteria, especially in an agricultural area where manure spreading is carried out in the winter on top of the snow.

Previous data from sampling points situated 50 to 100 feet from shore indicate that contamination from shore generally shows up within 12 to 48 hours after a heavy rainfall.

WATER TREATMENT

Lake and river water is open to contamination by man, animals and birds (all of which can be carriers of disease); consequently, NO RIVER OR LAKE WATER MAY BE CONSIDERED SAFE FOR HUMAN CONSUMPTION without prior treatment, including disinfection. Disinfection is especially critical if coliforms have been shown to be present.

Disinfection can be achieved by:

(a) Boiling
Boil the water for a minimum of five minutes to destroy the disease causing organisms.

(b) Chlorination using a household bleach containing 4 to 5 1/4% available chlorine.
Eight drops of a household bleach solution should be mixed with one gallon of water and allowed to stand for 15 minutes before drinking.

(c) Continuous Chlorination

For continuous water disinfection, a small domestic hypochlorinator (sometimes coupled with activated charcoal filters) can be obtained from a local plumber or water equipment supplier.

(d) Well Water Treatment

Well water can be disinfected using a household bleach (assuming strength at 5% available chlorine) if the depth of water and diameter of the well are known.

CHLORINE BLEACH
Per 10 ft. Depth of Water

Diameter of Well Casing in Inches	One to Ten Coliforms	More than Ten Coliforms
4	.5 oz.	1 oz.
6	1 oz.	2 oz.
8	2 oz.	4 oz.
12	4 oz.	8 oz.
16	7 oz.	14 oz.
20	11 oz.	22 oz.
24	16 oz.	31 oz.
30	25 oz.	49 oz.
36	35 oz.	70 oz.

Allow about six hours of contact time before using the water.

Another bacteriological sample should be taken after one week of use.

Water sources (spring, lake, well, etc.) should be inspected for possible contamination routes (surface soil, runoff following rain and seepage from domestic waste disposal sites). Attempts at disinfecting the water alone without removing the source of contamination will not supply bacteriologically safe water on a continuing basis.

There are several types of low cost filters (ceramic, paper, carbon, diatomaceous earth sometimes impregnated with silver, etc.) that can be easily installed on taps or in water lines. These may be useful in removing particles, if water is periodically turbid, and are usually very successful. Filters, however, do not disinfect water but may reduce bacterial numbers. For safety, chlorination of filtered water is recommended.

SEPTIC TANK INSTALLATIONS

In Ontario provincial law requires under Part 7 of the Environmental Protection Act that before you extend, alter, enlarge or establish any building where a sewage system will be used, a Certificate of Approval must be obtained from the Ministry of the Environment or its representatives. The local municipality or Health Unit may be delegated the authority to issue the Certificate of Approval. Any other pertinent information such as size, types and location of septic tanks and tile fields can also be obtained from the same authority.

(i) General Guidelines

A septic tank should not be closer than:

- 50 feet to any well, lake, stream, pond, spring, river or reservoir
- 5 feet to any building
- 10 feet to any property boundary

The tile field should not be closer than:

- 100 feet to the nearest dug well
- 50 feet to a drilled well which has a casing to 25 feet below ground
- 25 feet to a building with a basement that has a floor below the level of the tile in the tile bed
- 10 feet to any other building
- 10 feet to a property boundary
- 50 feet to any lake, stream, pond, spring, river or reservoir.

The ideal location for a tile field is in a well drained, sandy loam soil remote from any wells or other drinking water sources. For the tile field to work satisfactorily, there should be at least 3 feet of soil between the bottom of the weeping tile trenches and the top of the ground water table or bedrock.

DYE TESTING OF SEPTIC TANK SYSTEMS

There is considerable interest among cottage owners to dye test their sewage systems, however, several problems are associated with dye testing. Dye would not be visible to the eye from a system that has a fairly direct connection to the lake. Thus, if a cottager dye-tested his

system and no dye was visible in the lake, he would assume that his system is satisfactory, which might not be the case. A low concentration of dye is not visible and therefore expensive equipment such as a fluorometer is required. Only qualified people with adequate equipment are capable of assessing a sewage system by using dye. In any case, it is likely that some of the water from a septic tank will eventually reach the lake. The important question is whether all contaminants including nutrients have been removed before it reaches the lake. To answer this question special knowledge of the system, soil depth and composition, underground geology of the region and the shape and flow of the shifting water table are required. Therefore, we recommend that this type of study should be performed only by qualified professionals.

BOATING & MARINA REGULATIONS

In order to help protect the lakes and rivers of Ontario from pollution, it is required by law that sewage (including garbage) from all pleasure craft, including houseboats, must be retained in suitable equipment. Equipment which is considered suitable by the Ministry of the Environment includes (1) retention devices with or without re-circulation which retain all toilet wastes for disposal ashore, and (2) incinerating devices which reduce all sewage to ash.

Equipment for storage of toilet wastes shall:

1. be non-portable
2. be constructed of structurally sound material
3. have adequate capacity for expected use
4. be properly installed, and
5. be equipped with the necessary pipes and fittings conveniently located for pump-out by shore-based facilities (although not specified, a pump-out deck fitting with 1½-inch diameter National Pipe Thread is commonly used).

An Ontario regulation requires that marinas and yacht clubs provide or arrange pump-out service for the customers and members who have toilet-equipped boats. In addition, all marinas and yacht clubs must provide litter containers that can be conveniently used by occupants of pleasure boats.

The following "Tips" may be of assistance to you in boating:

1. Motors should be in good mechanical condition and properly tuned.
2. When a tank for outboard motor testing is used, the contents should not be emptied into the water.
3. If the bilge is cleaned, the waste material must not be dumped into the water.
4. Fuel tanks must not be overfilled and space must be left for expansion if the fuel warms up.
5. Vent pipes should not be obstructed and fuel needs must be dispensed at a correct rate to prevent "blow-back".
6. Empty oil cans must be deposited in a leak-proof receptacle, and
7. Slow down and save fuel.

EUTROPHICATION OR EXCESSIVE FERTILIZATION AND LAKE PROCESSES

In recent years, cottagers have become aware of the problems associated with nutrient enrichment of recreational lakes and have learned to recognize many of the symptoms characterizing nutrient enriched (eutrophic) lakes. It is important to realize that small to moderate amounts of aquatic plants and algae are necessary to maintain a balanced aquatic environment. They provide food and a suitable environment for the growth of aquatic invertebrate organisms which serve as food for fish. Shade from large aquatic plants helps to keep the lower water cool, which is essential to certain species of fish and also provides protection for young game and forage fish. Numerous aquatic plants are utilized for food and/or protection by many species of waterfowl. However, too much growth creates an imbalance in the natural plant and animal community particularly with respect to oxygen conditions, and some desirable forms of life such as sport fish are eliminated and unsightly algae scums can form. The lake will not be "dead" but rather abound with life which unfortunately is not considered aesthetically pleasing. This change to poor water quality becomes apparent after a period of years during which extra nutrients are added to the lake and return to the natural state may also take a number of years after the nutrient inputs are stopped.

Changes in water quality with depth are a very important characteristic of a lake. Water temperatures are uniform throughout the lake in the early spring and winds generally keep the entire volume well mixed. Shallow lakes may remain well mixed all summer so that water quality will be the same throughout. On the other hand, in deep lakes, the surface waters warm up during late spring and early summer and float on the cooler more dense water below. The difference in density offers a resistance to mixing by wind action and many lakes do not become fully mixed again until the surface waters cool down in the fall. The bottom water receives no oxygen from the atmosphere during this unmixed period and the dissolved oxygen supply may be all used up by bacteria as they decompose organic matter. Cold water fish, such as trout, will have to move to the warm surface waters to get oxygen and because of the high water temperatures they will not thrive, so that the species will probably die out (see Figure next page).

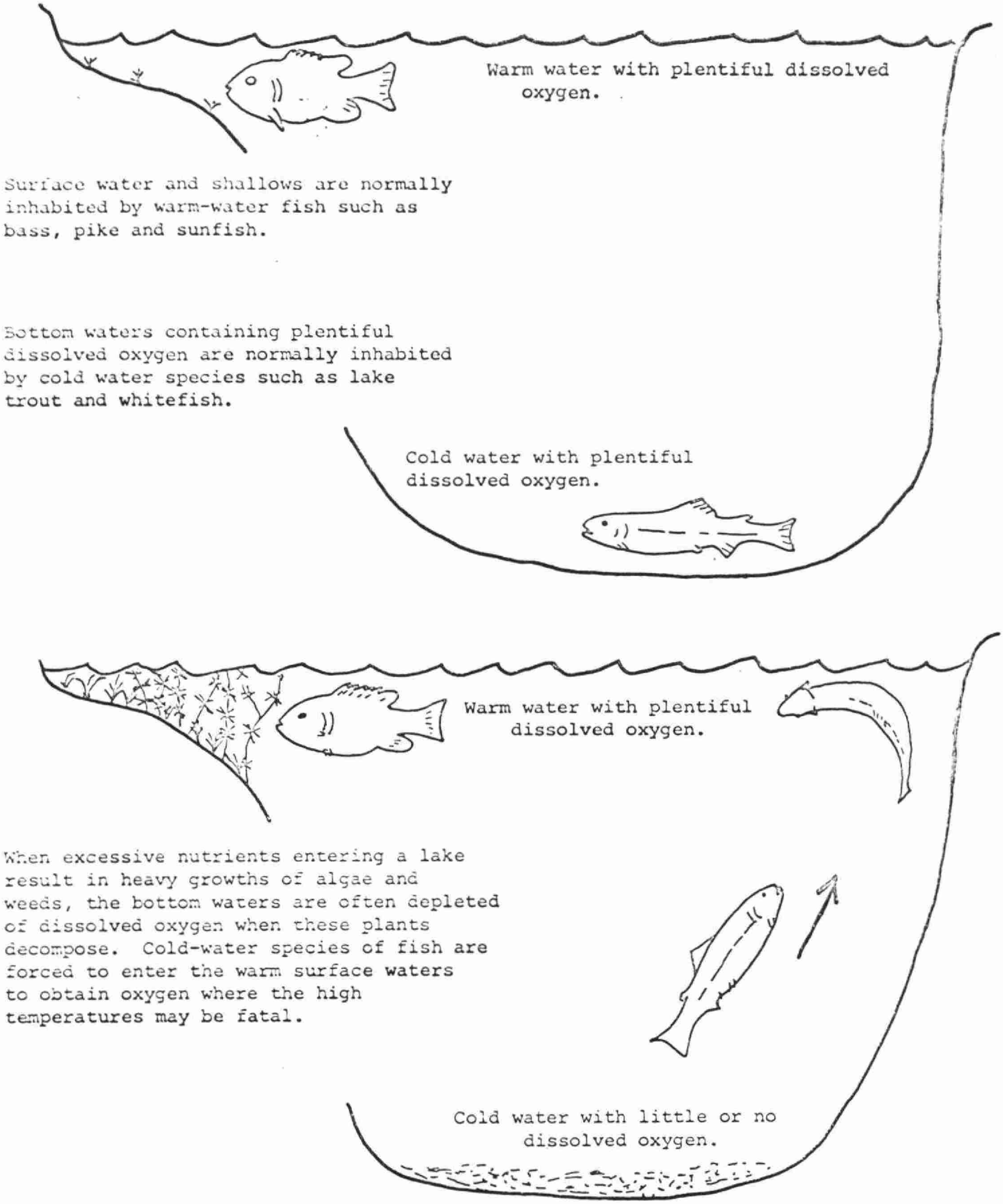


FIGURE A-1: DECOMPOSITION OF PLANT MATTER AT THE LAKE BOTTOM CAN LEAD TO DEATH OF DEEP-WATER FISH SPECIES.

Low oxygen conditions in the bottom waters are not necessarily an indication of pollution but excessive aquatic plant and algae growth and subsequent decomposition in the bottom waters can aggravate the condition and in some cases result in zero oxygen levels in lakes which had previously held some oxygen in the bottom waters all summer. Although plant nutrients normally accumulate in the bottom waters of lakes, they do so to a much greater extent if there is no oxygen present. These nutrients become available for algae in the surface waters when the lake mixes in the fall and dense algae growths can result. Consequently, lakes which have no oxygen in the bottom water during the summer are more prone to having algae problems and more vulnerable to nutrient inputs than lakes which retain some oxygen.

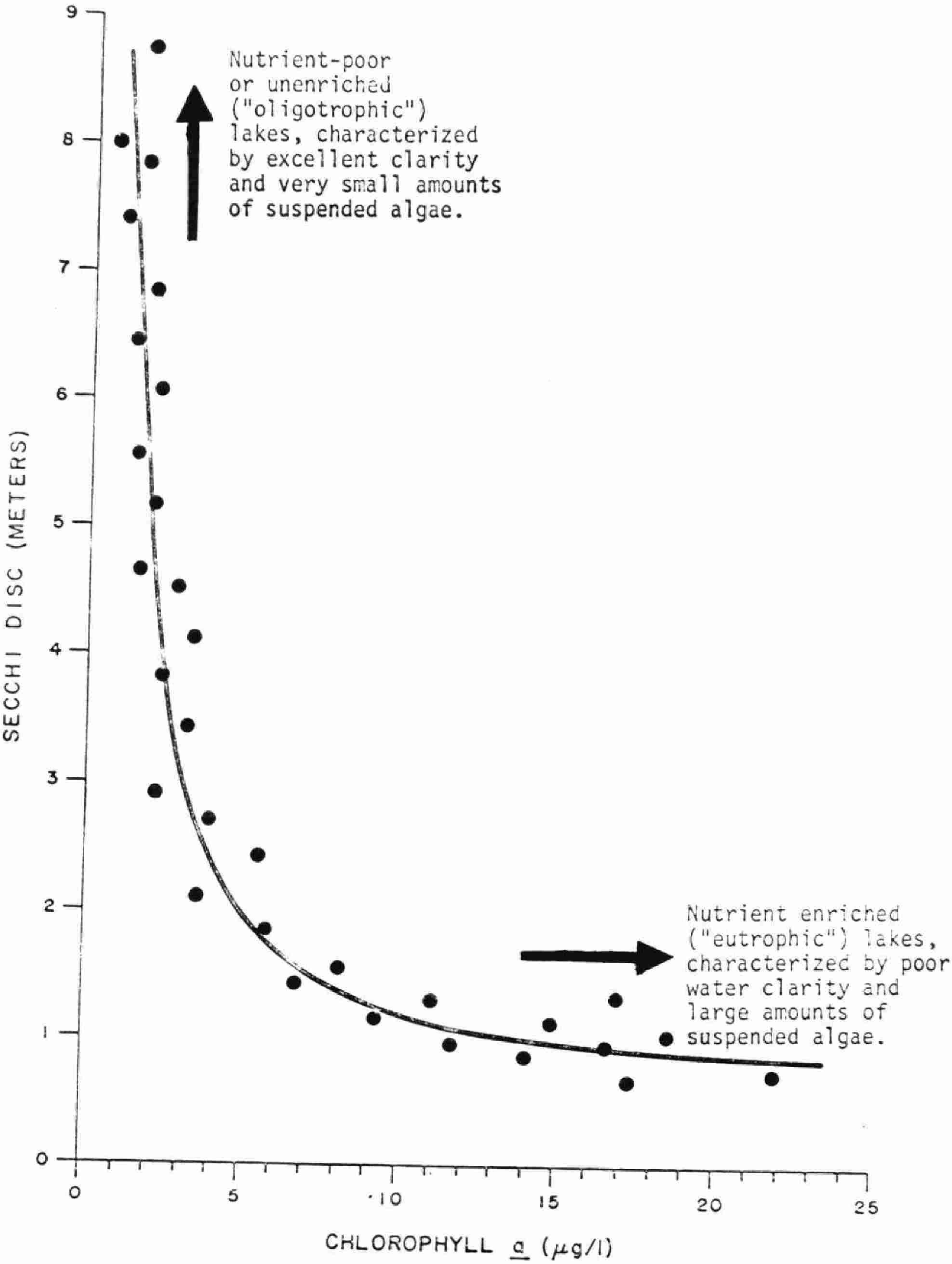
Like humans, aquatic plants and algae require a balanced "diet" for growth. Other special requirements including those for light and temperature are specific for certain algae and plants. Chemical elements such as nitrogen, phosphorus, carbon, and several others are required and must be in forms which are available for uptake by plants and algae. Growth of algae can be limited by scarcity of any single "critical" nutrient. Nitrogen and phosphorus are usually considered "critical" nutrients because they are most often in scarce supply in natural waters, particularly in lakes in the Precambrian area of the province. Phosphorus, especially is necessary for the processes of photosynthesis and cell division. Nitrogen and phosphorus are generally required in the nitrate-N (or ammonia-N) and phosphate forms and are present in natural land runoff and precipitation. Human and livestock wastes are a very significant source of these and other nutrients for lakes in urban and agricultural areas. It is extremely important that cottage waste disposal systems function so that seepage of nutrients to the lake does not occur since the changes in water quality brought about by excessive inputs of nutrients to lakes are usually evidenced by excessive growths of algae and aquatic plants.

The large amounts of suspended algae which materialize from excessive inputs of nutrients, result in turbid water of poor clarity or transparency. On the other hand, lakes with only small, natural inputs of nutrients and correspondingly low nutrient concentrations

(characteristically large and deep lakes) most often support very small amounts of suspended algae and consequently are clear-water lakes. An indication of the degree of enrichment of lakes can therefore be gained by measuring the density of suspended algae (as indicated by the chlorophyll a concentration - the green pigment in most plants and algae) and water clarity (measured with a Secchi disc). In this regard staff of the Ministry of the Environment have been collecting chlorophyll a and water clarity data from several lakes in Ontario and have developed a graphical relationship between these parameters which is being used by cottagers to further their understanding of the processes and consequences of nutrient enrichment of Precambrian lakes. The figure on the following page illustrates the above mentioned relationship.

In the absence of excessive coloured matter (eg. drainage from marshlands), lakes which are very low in nutrients are generally characterized by small amounts of suspended algae (ie. chlorophyll a) and are clear-water lakes with high Secchi disc values. Such lakes, with chlorophyll a and Secchi disc values lying in the upper lefthand area of the graph are unenriched or nutrient-poor ("oligotrophic") in status and do not suffer from the problems associated with excessive inputs of nutrients. In contrast, lakes with high chlorophyll a concentrations and poor clarity are positioned in the lower right-hand area of the graph and are enriched ("eutrophic"). These lakes usually exhibit symptoms of excessive nutrient enrichment including water turbidity owing to large amounts of suspended algae which may float to the surface and accumulate in sheltered areas around docks and bays.

Measurements of suspended algal density (chlorophyll a) and water clarity are especially valuable if carried out over several years. Year to year positional changes on the graph can then be assessed to determine whether or not changes in lake water quality are materializing so that remedial measures can be implemented before conditions become critical.



9
8
7
6
5
4
3
2
1
0
SECCHI DISC (METERS)
Nutrient-poor or unenriched ("oligotrophic") lakes, characterized by excellent clarity and very small amounts of suspended algae.
Nutrient enriched ("eutrophic") lakes, characterized by poor water clarity and large amounts of suspended algae.
0
5
10
15
20
25
CHLOROPHYLL a (μg/l)

CONTROL OF AQUATIC PLANTS AND ALGAE

Usually aquatic weed growths are heaviest in shallow shoreline areas where adequate light and nutrient conditions prevail.

Extensive aquatic plant and algal growths sometimes interfere with boating and swimming and ultimately diminish shoreline property values.

Control of aquatic plants may be achieved by either chemical or mechanical means. Chemical methods of control are currently the most practical, considering the ease with which they are applied. However, the herbicides and algicides currently available generally provide control for only a single season. It is important to ensure that an algicide or herbicide which kills the plants causing the nuisance, does not affect fish or other aquatic life and should be reasonable in cost. At the present time, there is no one chemical which will adequately control all species of algae and other aquatic plants. Chemical control in the province is regulated by the Ministry of the Environment and a permit must be granted prior to any operation. Simple raking and chain dragging operations to control submergent species have been successfully employed in a number of situations; however, the plants soon re-establish themselves. Removal of weeds by underwater mowing techniques is certainly the most attractive method of control and is currently being evaluated in Chemung Lake near Peterborough. Guidelines and summaries of control methods, and applications for permits are available from the Pesticides Control Section, Pollution Control Branch, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5.

PHOSPHORUS AND DETERGENTS

Scientists have recognized that phosphorus is the key nutrient in stimulating algal and plant growth in lakes and streams.

In the past years, approximately 50% of the phosphorus contributed by municipal sewage was added by detergents. Federal regulations reduced the phosphate content as P_2O_5 in laundry detergents from approximately 50% to 20% on August 1, 1970 and to 5% on January 1, 1973.

It should be recognized that automatic dishwashing compounds were not subject to the government regulations and that surprisingly high numbers of automatic dishwashers are present in resort areas (a questionnaire indicated that about 30% of the cottages in the Muskoka Lakes have automatic dishwashers). Cottagers utilizing such conveniences may be contributing significant amounts of phosphorus to recreational lakes. Indeed, in most of Ontario's vacation land, the source of domestic water is soft enough to allow the exclusive use of liquid dishwashing compounds, soap and soap-flakes.

ONTARIO'S PHOSPHORUS REMOVAL PROGRAMME

By 1975, the Government of Ontario expects to have controls in operation at more than 200 municipal wastewater treatment plants across the province serving some 4.7 million persons. This represents about 90% of the population serviced with sewers. The programme is in response to the International Joint Commission recommendations as embodied in the Great Lakes Water Quality Agreement and studies carried out by the Ministry of the Environment on inland recreational waters which showed phosphorus to be a major factor influencing eutrophication. The programme makes provision for nutrient control in the Upper and Lower Great Lakes, the Ottawa River system and in prime recreational waters where the need is demonstrated or where emphasis is placed upon prevention of localized eutrophication.

Phosphorus removal facilities became operational at wastewater treatment plants on December 31, 1973, in the most critically affected areas of the province, including all of the plants in the Lake Erie drainage basin and the inland recreational areas. The operational date for plants discharging to waters deemed to be in less critical condition, which includes plants larger than one million gallons per day (1 mgd) discharging to Lake Ontario and to the Ottawa River System, is December 31, 1975. The 1973 phase of the program involved 113 plants, of which 48 are in prime recreational areas. An additional 53 new plants, each with phosphorus removal, are now under development, 23 of which are located in recreational areas. The capacities of these plants range from 0.04 to 24.0 mgd, serving an estimated population of 1,600,000 persons.

The 1975 phase will bring into operation another 54 plants ranging in size from 0.3 to 180 mgd serving an additional 3,100,000 persons. Treatment facilities utilizing the Lower Great Lakes must meet effluent guidelines of less than 1.0 milligram per litre of total phosphorus in their final effluent. Facilities utilizing the Upper Great Lakes, the Ottawa River Basin and certain areas of Georgian Bay where needs have been demonstrated must remove at least 80% of the phosphorus reaching their sewage treatment plants.

CONTROL OF BITING INSECTS

Mosquitoes and blackflies often interfere with the enjoyment of recreational facilities at the lake-side vacation property. Pesticidal spraying or fogging in the vicinity of cottages produces extremely temporary benefits and usually do not justify the hazard involved in contaminating the nearby water. Eradication of biting fly populations is not possible under any circumstances and significant control is rarely achieved in the absence of large-scale abatement programmes involving substantial funds and trained personnel. Limited use of approved larvicides in small areas of swamp or in rain pools close to residences on private property may be undertaken by individual landowners, but permits are necessary wherever treated waters may contaminate adjacent streams or lakes. The use of repellents and light traps is encouraged as are attempts to reduce mosquito larval habitat by improving land drainage. Applications for permits to apply insecticides as well as technical advice can be obtained from the Pesticides Control Section, Pollution Control Branch, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5.